Importance of Nitric Nitrogen in Avocado cultivation

Related Crops

Nitrogen is a central ingredient in the structure of all amino acids, which form all structural (protoplasm) and functional proteins (enzymes), found in all living cells. N is a dominant part also in the chemical structure of chlorophyll and nucleic acids, as well as in secondary metabolites and precursors of plant hormones. Abundant supply of nitrogen is, therefore, a prerequisite for active vegetative growth, which serves as the basis for bountiful flowering, fruit-set and fruit growth and bulking up. The clever avocado grower must make sure that adequate nitrogen is supplied to the trees, at the right timing and optimal rates, maintaining optimal mutual ratio with all other nutrients. Too little application rate limits the vegetative growth, hence- fruit size and total fruit load. But excessive N application reduce flowering, fruit-set, fruit bulking-up, and fruit's internal quality, in terms of postharvest mesocarp (pulp) browning of the fruit, in *'Hass'*, *'Fuerte'* and *'Pinkerton'* cultivars. High attention must be paid to the nitrogen form supplied to the trees.

Plants take up their nitrogen from the soil mainly in the following forms:

Nitrate (NO_3^-)**.** Being an anion (negatively charged) it is mobile in the soil and absorbed readily into roots and leaves. it is barely adsorbed by soil's clays, hence, it is leached readily, by heavy rainfall and over-irrigation. Found in many high-quality fertilizers like potassium nitrate, calcium nitrate, magnesium nitrate and ammonium nitrate.

Ammonium (NH_4^+)**.** Being a cation (positively charged) it tends to be bound to the surfaces of soil clay particles, and thus- it does not move freely in the soil, and is not readily leached. Ammonium ions can be taken into the plant roots only if in the soil solution. When attached to the soil particles, they are converted to nitrate ions in 2-3 weeks, depending upon appropriate bacteria, soil moisture and temperature. Found in specialty fertilizers like ammonium nitrate, ammonium sulfate.

Amide (NH_2)**.** This N form is absorbed readily into roots and leaves, but being electrically neutral, it is not adsorbed by soil's clays, hence, it is mobile in the soil, and leached readily by heavy rainfall and over-irrigation. Additionally, it is sensitive to high temperatures, which massively volatilize it to gaseous ammonia, that is lost from the soil to the atmosphere. It is found in the highly concentrated, and inexpensive N carrier – urea (46%N).

The unique benefits of nitrate-based fertilizers for the avocado crop

· Most nitrates are very water-soluble, the grower can very easily dissolve them and apply to the soil by side-dressing or by fertigation. As nitrates are highly mobile in the soil, they are taken up passively and easily by the plant roots, swept by the transpiration stream, and are reduced in the leaves, to be combined with carbon skeletons (produced by photosynthesis), to form amino acids. When nitrates are foliar- applied, their route becomes even shorter, and their effect is very rapid.

· When nitrates are taken up, the avocado tree roots excrete OH^- anions to the soil. This helps trees growing in suboptimal-pH soils in producing an optimal local soil niche.

· Nitrates are highly compatible with all types of fertilizers and agrochemicals, enabling wide range of tank mixes.

· Its innate uptake competition with chloride and boron, makes it an effective tool against soil-, or water- driven high concentrations of these deleterious anions, to which the avocado tree is extremely sensitive.

In general, most plant species, except those that have undergone acclimation to acidic soils, grow better when supplied with nitrate-N, than with other N- species (Pilbeam & Kirkby, 1992)**.**

Nitrates are superior to ammonium- and ureic- fertilizers

· When ammonium cations are taken up by avocado roots, they are turned into amino acids in the root cells, by reacting with the sugars found in the roots. Thus, the sugars supplied to the roots for their respiration are rapidly consumed. This provokes marked sugar shortage, which undermines roots' performance, especially under elevated temperature events, that are rather common in sub-tropical climates, where most avocado plantations are found. Sugar depletion in the roots, also increases ammonium concentration in the roots, up to toxic levels, which provoke tree-scale damages.

· Nitrate-N is always dissolved in the soil solution, so it is drawn passively into the plant roots, avoiding energy investment by the plant. However, ammonium-N tends to adsorb to soil clay minerals, which reduces its availability to the roots. This ammonium will eventually pass a nitrification process, that will turn it into available nitrate, by soil bacterial activity, but this is a slow process. Therefore, when nitrogen has to be supplied "Just on time", nitrate is definitely the N source of choice.

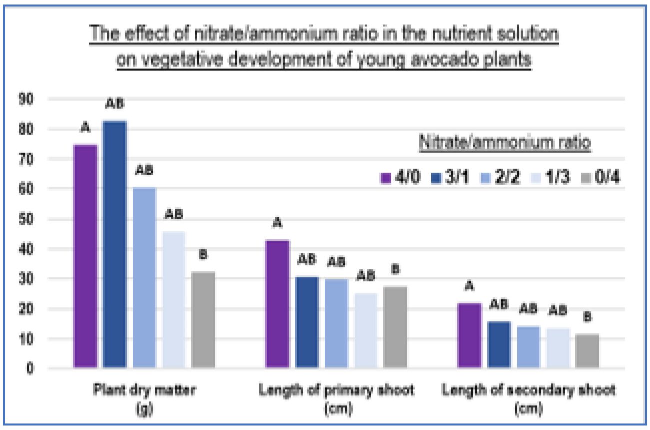
· Ammonium uptake by the roots also strongly competes with, and reduces the uptake of potassium, calcium and magnesium, whereas nitrate uptake enhances the uptake of the said cations, as well as all cationic micronutrients.

· Unlike ammonium-, and urea- based N fertilizers, nitrates are not volatile, hence, are not lost to the atmosphere. Nitrates are, thus, much more environmentally friendly and feature much higher N-use efficiency. But, nitrates are easily washed away by percolation and run-off. Therefore, nitrate fertilizers need to be applied frequently and at relatively low rates. This is also the optimal irrigation regime for avocado trees.

· Avocado plantations suffer seriously from the devastating fungus *Phytophthora cinnamomi*, that causes root rot disease. Calcium ions provided as calcium nitrate have a mild antifungal effect. Ammonium ions are similarly noxious to the fungus, but the concentration required is also toxic to avocado feeder roots, (Pegg-wheel, 2020).

The following studies can prove that the abovementioned scientific claims based on field experiments.

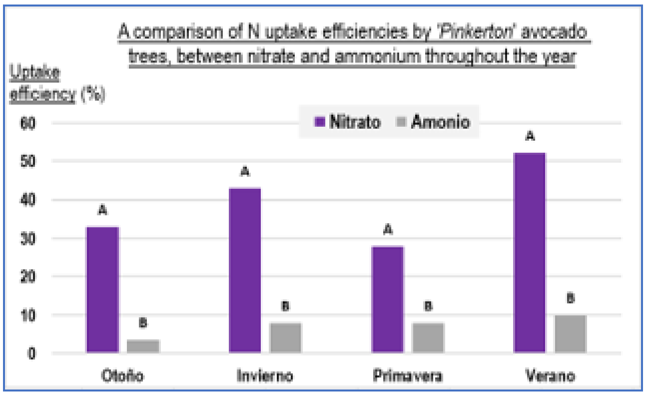
México. High nitrate/ammonium ratio enhances vegetative development of young avocado plants



Lobit & al, 2007, of Michoacán University, grew young *'Hass'* plants, in a greenhouse, on hydroponic solutions, in which the nitrogen sources of the growth solutions had the following nitrate/ammonium proportions: 4/0; 3/1; 2/2; 1/3, and 0/4, while all other mineral components of the solutions were identical. Four months later, plants development was compared. The following figure shows clearly that increasing the share of the nitrate enhances dry matter accumulation, shoot extension and branching of the young avocado plants.

Israel. High nitrate/ammonium ratio enhances N-uptake by 2-years old avocado plants, at all seasons**.**

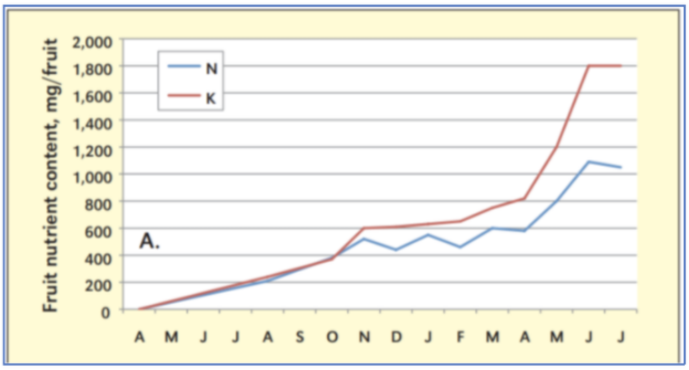
The study of Zilkah et al. (2000), carried out with *'Pinkerton'* avocado trees, showed that both soil-applied N- forms, were distributed at a similar manner among roots, trunk, branches and leaves. But the uptake efficiency of nitrate-N (applied as potassium nitrate) was drastically higher than that of the ammonium-N (applied as ammonium sulfate), in each one of the plant organs, and during each one of the year's seasons. Highest uptake efficiency took place in the summer, exactly when the total dry matter of the avocado tree was greatest throughout the entire year, (data not shown).



Final conclusion

The above-mentioned theory and practice show the relative advantage of nitrate over ammonium for the avocado tree, yet, it is recommended to combine both N forms at nitrate/ammonium ratio of 3-4/1, on an annual basis, due to several virtues of ammonium.

Figure 1: N & K accumulation curves in 'Hass' avocado fruit from bloom to harvest. California,
Ref.: Rosecrance, 2012



The issue of N uptake curve during the bi-annual fruiting cycle, of "On" and "Off" years

Nitrogen uptake of avocado trees on an alternate bearing cycle. These values are from a 'Hass' orchard near Moorpark, CA which blooms in February and is harvested in July. For both "on" and "off" trees, very little N is taken up during the dormant period. The time of greatest uptake is around March through May, when exponential growth of the maturing crop, fruit-set of the new crop, and the spring flush take place. In "on" years, more of the spring N uptake is allocated to the fruit, while in "off" years, more is allocated to the new shoots. In "on" years, uptake is also high from July through October as the new crop has its first stage of rapid growth; however, uptake at this stage is slower in "off" years.

	Actual values found in experiments			
South Africa	California (USA)	Israel	Nayarit (Mexico)	Michoacan (Mexico)
13	28	11	26	24.5–32.5

Nitrogen deficiency symptoms: Older leaves initially turn pale green to yellow. Veins lighter in colour than the rest of the leaf blade. Affected leaf edges may roll upward. At severe deficiency- leaf tip shows scorching, and leaf drop may occur.

Excess symptoms: fruit pulp becomes grey in cv. 'Pinkerton'.

Situations increasing the incidence of N deficiency: Sandy, lightly structured soil. Extremes of pH. Poor levels of organic matter. High rainfall or heavy irrigation (leaching). Large quantity of crop residue which use soil N for decomposition. Crops with rapid growth habit. Mo deficiency decreases N use efficiency, due to little activity of the nitrate reductase enzyme.

Leaf samples (~40 leaves per a homogenous block) are taken during late-August – October, from 5-7-month-old spring-flush leaves, about 5-6 from the end of the flush, from non-fruiting branches). Ref.: Bender, 2016, y otros

Organo / Variedad	Deficiente (%)	Bajo (%)	Suficiente (%)	Alto (%)	Exceso (%)
Oja / *Hass*	<1.40	<1.8	2.00–2.20	2.21–2.70	>2.71
Oja / *Fuerte*	<1.30	1.31–1.6	1.61–2.00	2.01-2.49	>2.50
Oja / *Lula*			1.80–2.20		
Oja / Otros	<1.30	1.31–1.89	1.90–2.20	2.21-2.49	>2.50
Fruta (Otono- Nov)			<1.5		
Fruta (Invierno- Feb)			<1.0		

Nitrogen deficiency symptoms:

A. On the leaves
- Smaller than usual.
- Uniform chlorosis of the leaf
- Leaves with yellow veins (severe deficiency), see photo ....
- Premature defoliation

B. Low vegetative vigor

C. Reduced yields

D. Photo 1: different stages in the severity of N- deficiency of cv. *'Fuerte'* leaves.

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